TECHNIQUE TRAINING IN ALPINE SKI RACING: FORCED MOVEMENT CHANGES BY A SPECIFIC DEVICE

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A crucial point of modern methods in motor learning is a high degree of exercise variability. Especially in alpine skiing, where athletes have to compensate external variability, adequate exercises have to be offered. To fulfill these requirements, a specific training device with the possibility of different settings was developed. In the present study we analyzed the function of three settings and short time adaptation effects during a training session. A mixed training protocol (race & various device settings) was compared to a normal training session. In two of three settings runtimes were significantly higher. A repeated usage of one setting led to an adaptation in runtime (sig. faster). For partial runtimes no adaptation was found. No adaptation of the original race setup was observed after applying several variable settings. The overall force distribution between inside and outside leg was not, or only marginally, influenced by the usage of the device. Very strong effects were found in the force distribution within a leg. It can be concluded that the usage has only little impact on general movement patterns (macroscopic level), but a substantial one on microscopic level. Hence, the new device generates exactly those movement variations which are recommended for modern technique training.

KEY WORDS: alpine skiing, technique training, motor learning.

INTRODUCTION: Modern theories in motor learning are based on Bernstein's approach of coordination. The basic idea of his approach is the assumption that our central nervous system has a compensation function between the necessary movement forces and the occurring external forces (Bernstein, 1975). Based on Bernstein's work, the aim of the technique training process should not be only learning to compensate, but also learning to use the external forces for the movement execution. Since this compensation function is coupled to a movement dependent degree of variability, Bernstein's early ideas had an important impact on actual methods in motor learning (e.g. Schöllhorn, differential learning approach, 1999).
In Alpine ski racing we have movements which have constantly cyclic components (turn by turn), but, compared to other cyclic movements (e.g. running), external circumstances which cause a high variability (e.g. snow conditions, slope inclination and course setting). In terms of Bernstein this means, that the compensation function undergoes an extraordinarily high variability. As a consequence we have to consider this in the technique training process of alpine ski racers. There is a necessity to find exercises in which the general movement forces (macroscopic level) are close to those in the race technique, but at the same time allow a high number of planned substantial differences for the compensation function of the central nervous system (microscopic level).

Forward (FO)

Backward (BA)

Figure 1: Different settings of the training device (left) and a racer performing a turn (right)

To fulfill these requirements, we developed a specific training device (SensoWip) which is based on a ´see-saw´ between the binding and the ski. It can be cushioned by springs or fixed with a forward/backward inclination. The SensoWip and its basic variations are shown in Figure 1. Different degrees of spring stiffness and combinations between the basic settings (left / right) give the possibility of a high number of variations (>20). In a pilot study we found no substantial differences between basic settings and the race setup in measured macroscopic movement patterns (overall forces left & right; knee angle & hip angle). Contrary to this strong differences were found on a microscopic level (force distribution in sagittal plane). Due to the fact that this behavior was wanted we proceeded to investigate effects of the SensoWip in a real training situation. The purpose of the present study was to analyze differences on runtime and selected force parameters (macroscopic and microscopic) of various settings in comparison to the race setup. Additionally, we wanted to examine short time adaptation effects during a training session of 9 runs with temporal usage of the SensoWip.

METHOD: Thirteen junior racers (national level, age 16.2) were divided into an experimental group (EG; n=6) and control group (CG; n=7) according to their skiing level. Both groups performed an extended training session with nine runs on a 22 gate giant slalom (GS) course (runtime 39s). The CG used normal GS race setup for all their runs. The protocol of the EG can be seen in Table1, row2. The setup springs (SP) and setup forward (FO) were used only once. The setup backward (BA) was used several times to get information about the adaptation processes caused by longer usage of a setting. The subjects had no experience in using the SensoWip. Both groups performed two warm-up runs without gates and one with gates (task 80% of maximum speed). Subjects of the EG got used to the SensoWip by performing the second warm-up run (without gates) with the setting SP. To avoid external influences (e.g. slope changing) the starting order was fixed (alternating EG-CG) for all runs.
For runtime analysis the overall time (gate1 to gate22) and the intermediate time (at gate 12) were measured. First absolute values of the overall runtimes were analyzed, and then partial runtimes of the various settings were compared relatively to the prior race setup run. Dependent and independent t-tests were used to compare the variables between and within the groups.
Additionally to runtime aspects, the dynamic behavior of one subject in the EG was analyzed. The ground reaction forces were recorded bilaterally using the Pedar Insole System (Novel, Munich). As a macroscopic pattern the load distribution between inside and outside leg was calculated (mean over each single turn). To identify microscopic differences and adaptations the change of force distribution in sagittal plan (forefoot/heel) was considered. The definition of the different areas (analyzing masks) was analogue to previous studies (Raschner, 2001). The calculated parameter is the value of dominance in forward or backward direction (mean over each single turn). For statistical analysis in both variables (load on outside leg & dominance in sagittal plane) the effect size (η^2) was calculated to point out the degree of association between effect and dependent variable. The outside leg of 17 turns (turn 1, 2, 22 and min/max turns were excluded) was treated as independent sample.

RESULTS and DISCUSSION:

Runtimes (Table 1): Considering the runtimes during various settings, we found that the runtime of the EG compared to CG was significantly higher for setup FO (p<.021) and backward1 (BA1, p<.027). The increase of ~6% in both situations can be seen as substantial but experts assign still a high affinity to the race setup. On the other hand, the settings SP and backward2 (BA2) show no differences in run time compared to CG. For SP it can be concluded that the requirements in additional or new compensation strategies for the neuromuscular system (NMS) were easy to manage. The differences between BA1 and BA2 (p<0.004) can be explained by an adaptation using the device repeatedly. It can be interpreted that a repeated use of the initially very challenging setting FO and BA leads to quite fast adaptation concerning the requirements for the NMS.

The observed adaptation from BA1 to BA2 in the overall runtime seemed to have happened between the runs and not during the run (see results of partial runtimes in the following part). Between the two runs subjects had the possibility to ski a couple of turns without gates which seems to be positive for adaptation while using the device. Doing the exercises the first time, one could expect that there is some kind of adaptation from the 1st to the 2nd half of the course. The partial runtimes of Table 1 showed no significant differences between 1st and 2nd half of the run. Therefore it can be concluded that adaptation within the run is difficult to reach. The reason can be seen in high requirements which a given trajectory in a GS course on the NMS has. If we analyze only the first half of the run for several setups one can observe that the difference to the prior race setup is in BA highest, FO medium and SP lowest (BA1-FO $p<0.035$; FO-Sp $p<0.021$). From a methodological point of view this means, that the requirements on the NMS are different and should be considered in using the SensoWip. The overall runtimes of the EG in the race situations pre and post the current exercises showed no differences to the CG in the same run number. Therefore it can be concluded that the use of the SensoWip in a single training session with a low amount of exercise runs has no impact on the performance with the race setup.

Table 1 Results of runtime and partial runtimes (1st half / 2nd half) of EG (n=6) and CG (n=7)

RunNo		1	2	3	4	5	6	7	8	9
Situation	EG	Race	Springs	Race	Forward	Race	Backward1	Backward2	Race	Race
	CG	Race	Race	Race	Race	Race	Race	Race	Race	Race
Runtime [s]	EG	38,12	39,00	38,48	40,83	37,96	41,69	39,36	39,08	38,11
		0,96	*1,09*	*1,36*	*1,72*	*1,54*	*1,32*	*1,43*	*1,03*	*1,13*
	CG	38,42	38,92	38,76	38,50	38,46	39,30	38,84	38,72	38,58
		1,29	*1,16*	*1,29*	*1,42*	*1,66*	*1,51*	*1,40*	*1,49*	*1,50*

RunNo(x)-RunNo(y)		2-1	4-3	5-6	5-7
1st half [diff in %]	EG	1,97	5,36	8,80	3,98
		2,37	*3,65*	*3,69*	*1,25*
2nd half [diff in %]	EG	2,52	6,07	6,87	3,33
		2,65	*2,56*	*2,98*	*2,52*

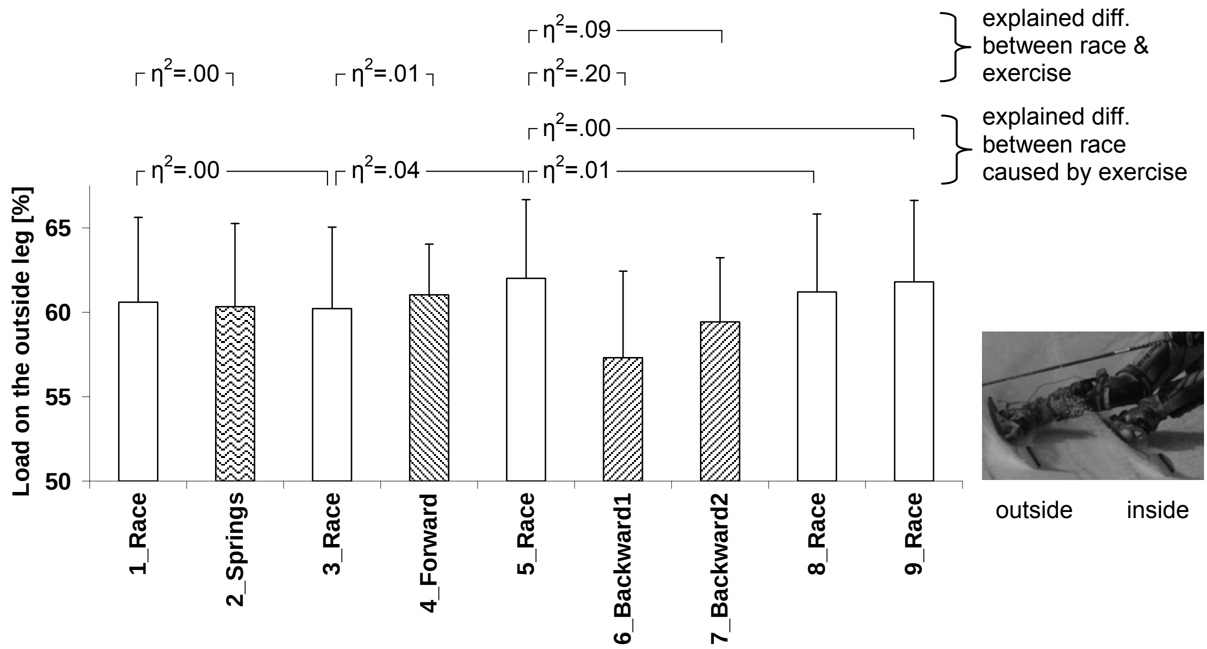

Figure 2: Overall Force distribution between inside and outside leg; n=17 turns, one subject of EG

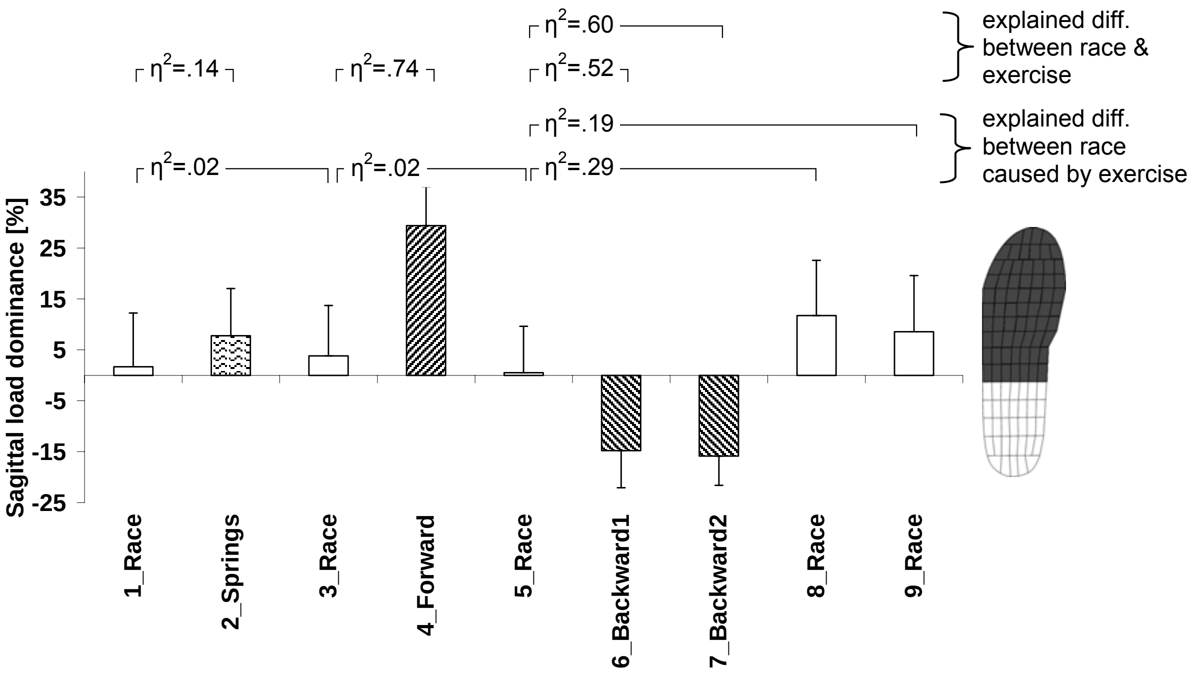

Figure 3: Force distribution of the outside leg in sagittal direction; n=17 turns, one subject of EG

Dynamics: Figure 2 represents the results of the macroscopic parameter load on the outside leg. It was found, that the mean load on the outside leg was in all runs similar (57% - 62%). The different settings did not influence the load distribution substantially. Only in setup BA1 slight differences were found which can be accounted to 20% by the test condition. The low effect observed in BA2 can be interpreted with some kind of adaptation process like already identified in the runtimes between BA1 and BA2. No effect between several race setup runs caused by the different settings was observed. Figure 3 represents the results for the microscopic parameter sagittal load dominance. Contrary to the macroscopic results strong microscopic effects were identified by the use of the SensoWip. Only a low effect was observed in SP. Using the setup FO the forefoot was dominantly loaded higher (~29%) than the rear foot (η^2=.74). In BA1 and BA2 an opposite sagittal dominance with ~-15% was identified (η^2=.52 and η^2=.60). Thus no adaptation between BA1 and BA2 in this parameter was found. SP and FO didn't influence the following race setup runs. But an adaptation process using the setting BA was observed. Compared to the prior run, after BA1 and BA2 a higher forefoot load was found (η^2=.30). Furthermore this effect was also observable in the last race setup run in a smaller value (η^2=.19).

CONCLUSION: The three examined settings seem to have different requirements on the compensation function of our NMS and allow planed variations. This can be observed in different run time performance and basic movement patterns (sagittal load). A crucial point in the evaluation of the SensoWip is not only the possibility of variations, but also the general technique affinity to the race situation. With only relatively slight increases in runtimes and low influence on the overall force distribution, the different settings seem to fulfill this criterion. Due to the facts that the sagittal load distribution is a dominant criterion for steering an alpine ski and that short time adaptations through the use of the SensoWip seem to be possible, this will be the main topic for further investigations. A further aim is to implement the SensoWip in the daily training process to get fundamental feedback according the effectiveness from a practical standpoint.

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